

## **Shallow Water Acoustics Studies**

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Grant Number: N00014-14-1-0040  
<http://acoustics.whoi.edu/sw06/>

### **LONG TERM GOALS**

The long term goals of our shallow water acoustics work are to: 1) understand the nature of low frequency (10-1500 Hz) acoustic propagation, scattering and noise in shallow water when strong oceanic variability is present in the form of fronts, eddies, boundary layers, and internal waves (using the SW06 and QPE data, primarily) and 2) begin planning a 2018+ field experiment to look at the complicated boundary between deep and shallow water, i.e. the slope/canyon region. (Dates for any experiments are approximate.)

### **OBJECTIVES**

Our primary objectives this year were to: 1) finish manuscripts on the QPE and SW06 shallow water acoustics/Uncertainty work, and submit them for publication, 2) begin the 2018 (shelfbreak, slope and canyon) experimental planning, both on an individual basis, and in conjunction with the whole ocean acoustics community, 3) continue work on modeling scattering by coastal internal waves and other features by developing simple “ocean feature model” based expressions for horizontal array coherence, temporal coherence, transmission loss, and scintillation index, 4) look at climate change effects in shallow water, 5) further develop the theory of scattering of sound from a rough elastic solid seabed, and 6) write a book chapter on Shallow Water Acoustics for the book on “Practical Underwater Acoustics” being edited by Bjorno and Neighbors.

### **APPROACH**

We devoted effort this year towards publishing one of the last SW06 papers, on acoustic scattering from crossing nonlinear internal wave trains. This is submitted for publication. The two SW06/QPE papers in preparation are on: 1) the azimuthal dependence of TL, and how it compares at similar coastal sites worldwide, and 2) a demonstration that the predictive probability of detection (PPD) formalism of Dyer and Abbot works well, using QPE field data. The experimental planning for a shelfbreak/slope/canyon experiment has been placed “on hold” by ONR for the time being, though some of that planning has been useful in designing a shallow component to the current Arctic acoustics experiment. Our third, fourth and fifth objectives are part of our continuing research, which we hope to have publishable results upon by next year. The sixth objective has been accomplished, and the book chapter submitted.

## **WORK COMPLETED/ACCOMPLISHMENTS**

As discussed above, we have a book chapter and a peer reviewed paper submitted for publication. Due to the PI taking on the new responsibility of Editor in Chief of the Journal of the Acoustical Society of America, and also due to some serious health issues (three major operations in spring, 2015), somewhat less was accomplished than was desired this past year. This situation will hopefully improve in 2016.

## **RESULTS**

The paper on crossing waves is a physics based look at a common coastal oceanography/acoustics phenomenon, and the book chapter should be useful to the ocean acoustics community students and practitioners (its intended audience). We have partial results from the other objectives, which we hope to complete next year.

## **IMPACT/APPLICATIONS**

The impact of our experiment should be: 1) an increased understanding of the propagation of sound through complicated coastal oceanography, 2) an eventual capability to model these effects for use in sonar performance prediction applications, and 3) showing that the PPD formalism for detection could be a useful extension of the usual sonar equation ROC curves.

## **TRANSITIONS**

One eventual transition of our analyses will be to ONR's Uncertainty DRI program, where the interest is in "the error bars" in ocean acoustic field and system performance prediction. Another transition is the use of our SW06 internal wave data to verify a large "coastal oceanography plus internal wave" model being developed under a MURI that can eventually be used as a Navy standard model that works at all ocean scales down to the internal waves and finescale. Finally, the simple feature model expressions for coherence length, coherence time, TL and SI that we are generating could be very useful in showing how accurate one needs to be with larger scale models and theories in order to predict these quantities at an acceptable level.

## **RELATED PROJECTS**

The SWARM acoustics/internal wave study, the PRIMER acoustics/shelfbreak front study, and ASIAEX experiment were direct predecessors of SW06, and examined some of the same acoustic scientific issues, only with far fewer measurement resources. The "Non-linear internal waves initiative" (NLIWI) was strongly related to our SW06 effort via the environmental support that the oceanographic moorings (and other PO measurements) provided. The QPE experiment, stressing acoustic and environmental uncertainty in a coastal environment, is also related. Finally, the MURI for full 3D modeling of coastal internal waves and acoustics will directly use our SW06 data for model verification.

## PUBLICATIONS

- [1] A.A. Shmelev, J.F. Lynch, and Y.-T. Lin and H. Schmidt, “Low-frequency acoustic propagation through crossing internal waves in shallow water” *J. Acoust. Soc. Am.* (2015). [submitted, refereed]
- [2] J.F. Lynch and A.E. Newhall, “Shallow Water Acoustics”, Chapter 7 of book on “Practical Underwater Acoustics”, Bjorno and Neighbors, eds. (2015) [submitted, refereed]